

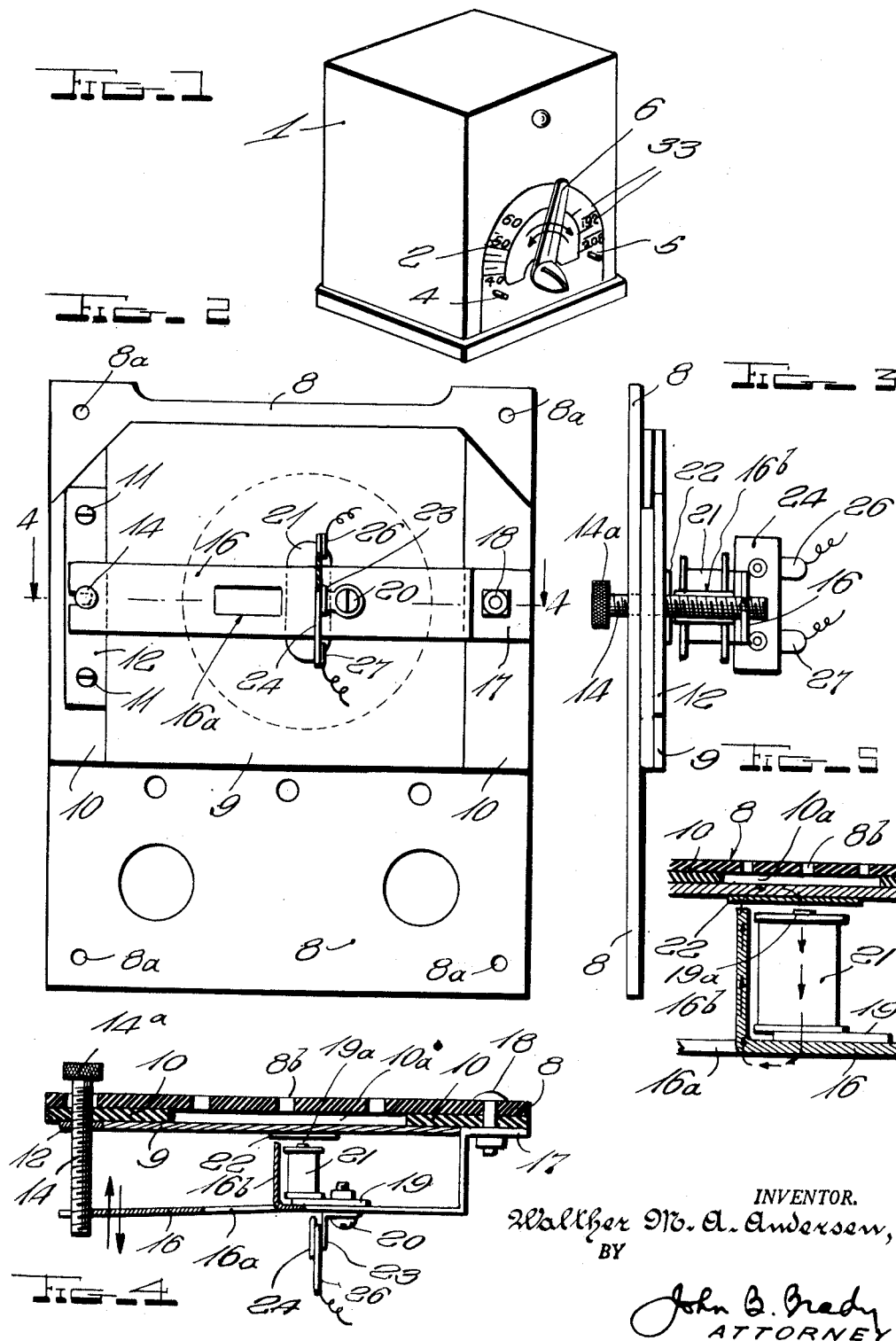
Sept. 19, 1950

W. M. A. ANDERSEN  
ELECTRONIC METRONOME

2,522,492

Filed May 29, 1946

2 Sheets-Sheet 1



Sept. 19, 1950

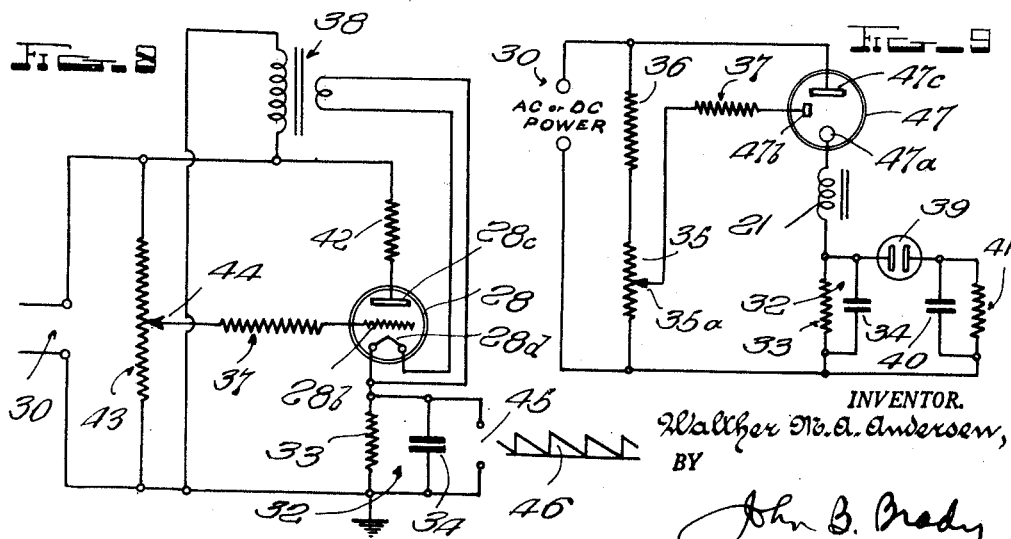
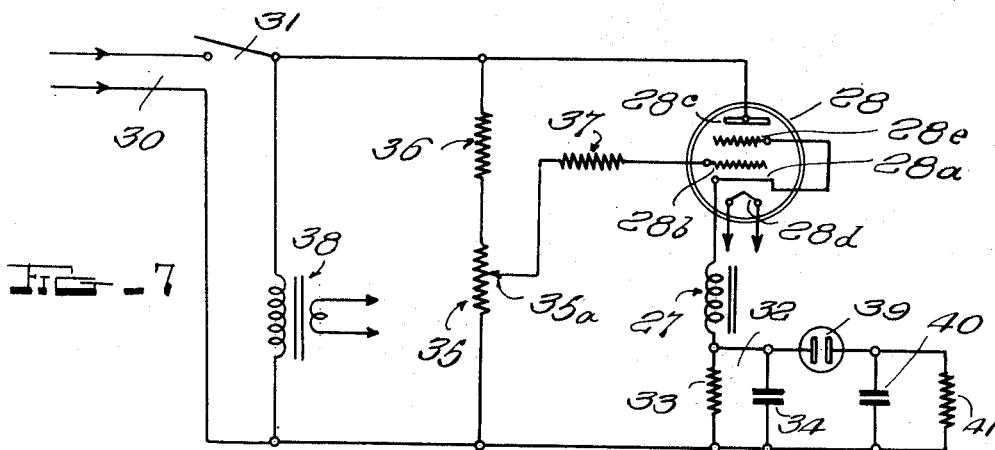
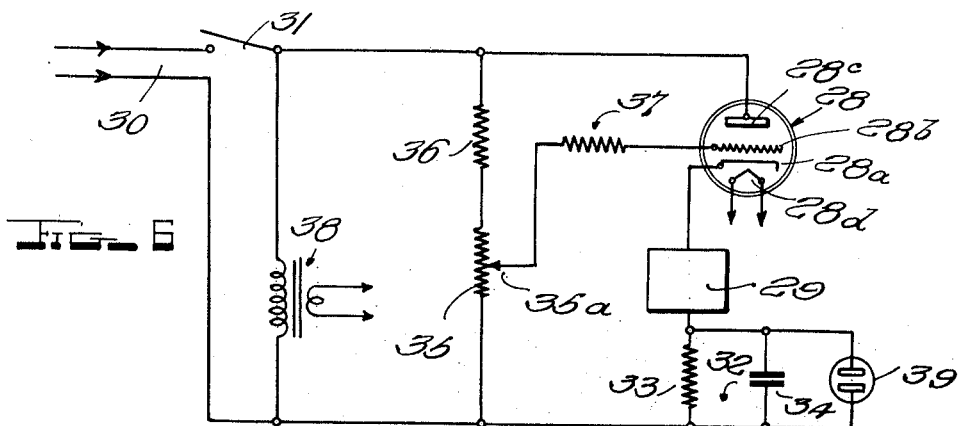
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ELECTRONIC METRONOME

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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

2,522,492

## ELECTRONIC METRONOME

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6 Claims. (Cl. 175—381)

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My invention relates broadly to metronomes and more particularly to an improved circuit and structure of metronome embodying electronic principles.

One of the objects of my invention is to provide a novel circuit arrangement for a metronome by which a timed, visual and audible indication may be produced.

Another object of my invention is to provide a construction of electronic metronome in which no moving parts are used to control the timing of audible signals.

Another object of my invention is to provide an electronic metronome including a source of illumination within the instrument so that a simultaneous flash of light is produced with each audible beat.

Still another object of my invention is to provide an electronic circuit arrangement for metronomes in which the accuracy of beat repetition is exceedingly high and is controlled as to accuracy by the frequency of a domestic alternating current power supply line.

Still another object of my invention is to provide a circuit arrangement embodying a grid-controlled rectifier of the gaseous type tube such as a thyatron or cold cathode type tube for controlling a combined audible and visual repeating indication.

Still another object of my invention is to provide a construction of metronome of the electronic type including means for controlling the amplitude of the audible ticks or beats to meet various conditions encountered.

Still another object of my invention is to provide an adjustable electronic metronome in which the frequency of the repeated ticks or beats may be readily controlled in an instrument which is extremely compact in size and simple in manufacture on a mass production scale.

Other and further objects of my invention reside in an electronic metronome and circuit arrangement therefore as set forth more fully in the specification hereinafter following by reference to the accompanying drawings in which:

Figure 1 is a perspective view of the metronome of my invention; Fig. 2 is an elevational view of the adjustable magnetic actuating means and the sound-reproducing diaphragm of the audible responsive device employed in the metronome of my invention; Fig. 3 is a side view of the adjustable magnetic actuator and sound-reproducing diaphragm illustrated in Fig. 2; Fig. 4 is a transverse sectional view taken sub-

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stantially on line 4—4 of Fig. 2; Fig. 5 is a theoretical view illustrating the distribution of magnetic flux through the audible responsive device in the metronome; Fig. 6 is a schematic diagram of one circuit arrangement employing the principles of my invention; Fig. 7 is a modified circuit arrangement of the metronome of my invention; Fig. 8 shows a further modified form of circuit embodying the principles of my invention and which may be employed as a source of a sawtooth wave form usable in the electronic art; and Fig. 9 illustrates a cold cathode type of metronome circuit embodying my invention.

My invention is directed to an electronic type of metronome for generating audible sounds accompanied by visual indications for the purpose of marking or measuring time both audibly and visually. The electronic metronome of my invention is valuable in the musical art wherein mechanical devices have heretofore been employed for producing audible sounds to set the rhythm. The electronic metronome of my invention contains no moving parts to control the timing of audible responses, and includes a source of illumination which produces a simultaneous flash of light to accompany each audible beat. The instrument contains no parts subject to excessive wear or excessive servicing so that maintenance problems are minimized. The frequency of the beat repetition rate is controlled by the frequency of the alternating current domestic power supply line from which the instrument is energized, and this frequency may be adjusted within a wide range of limits broad enough to cover all of the requirements of rhythmic coordination or in the training of groups of students, etc.

The metronome of my invention comprises a grid controlled gas-filled type tube such as a thyatron or cold cathode type tube in which the power supply is furnished from the domestic power line. The circuit arrangement of my invention is adaptable to both alternating current and direct current operation. In the circuit of my invention, provision is made for dropping the power supply potential to a value suitable for exciting the cathode of the thyatron if a thyatron is used. In alternating current applications of the circuit of my invention, the power supply which is supplied to the thyatron by the line circuit is suitably reduced through a transformer for energizing the cathode of the thyatron.

The circuit which is associated with the grid-

controlled rectifier includes input and output means wherein the input means includes a multiplicity of adjustable resistors, and the output means includes an audible and visual indicating means in association with a basic timing circuit consisting of a resistor and a condenser, and wherein the resistor and condenser constitutes a mutual coupling between the input and output means. I further modify the visual indicating means by utilizing an auxiliary condenser and resistor for minimizing effects of variations found in types of visual indicating lamps used in the circuit of my invention, and for compensating for such variations. The adjustable resistors in the input means are selected in very special value in relation to the values of the basic timing circuit consistent with the mutual coupling means between the input and output means. The values of the resistors in the input means are so selected that the calibrations on the beat frequency dial of the metronome may be spread in a predetermined desired manner for the gradual increase or decrease in the frequency of the audible beat. The value of the resistance and capacity in the basic timing circuit are selected for the logarithmic or exponential decay of the cathode potential, whereas, the values of the resistors in the input means are selected so that, with variations in grid potentials, a desired calibration can be achieved.

Referring to the drawings in detail, reference character 1 designates a cabinet structure forming a housing for the components of the metronome of my invention. The housing carries a calibrated scale 2 on the front thereof having graduations indicated at 3 thereon for timing the beats which are reproduced by the metronome. There are limit stops 4 and 5 at opposite ends of the scale 2 between which the indicator or pointer 6 is adapted to be angularly moved under control of adjustment knob 7. The indicator or pointer 6 is formed from transparent material through which the calibrations 3 on scale 2 are readily visible and readable. The pointer indicator 6 is movable counterclockwise to decrease the frequency of the beats and is shifted clockwise to increase the frequency of the beats.

I have shown in Figs. 2-5 the rear panel 8 of the cabinet structure which may be secured by screw devices passing through apertures 8a in the rear of the cabinet structure 1. The rear panel 8 is apertured at 8b for the passage of sound waves emanating from the diaphragm 9. The diaphragm 9 is formed from balsa wood, which has been found to be suitable in reproducing the beats or ticks of the metronome. The balsa wood diaphragm 9 is secured in position upon spacer member 10 which is fastened to the rear of the panel 8 by appropriate securing screws represented at 11 which extend through the panel 8 and securing strip 12. Spacer 10 is apertured as represented at 10a for the passage of the sound waves from diaphragm 9 through the apertures 8b in the rear panel 8.

The securing strip 12 is screw-threaded for the passage of the screw-threaded adjustment screw 14 which projects through the rear of panel 8 and is provided with the knurled adjustment head 14a. The adjusting screw 14 engages the end of the strip 16 of magnetic material. The strip 16 extends transversely of the diaphragm 9 and is angularly bent toward the spacer member 10 and terminates in an angular securing bracket represented at 17. The bracket 17 is suitably secured by means of screw 18 to the rear panel 8

so that the strip 16 is spacially related to the rear of diaphragm 9.

The strip 16 carries substantially centrally thereof the magnetic angle member 19 which is secured thereto by screw member 20. The magnetic angle member 19 forms a pole piece on which the magnetic bobbin 21 is wound. The magnetic angle 19 terminates in the pole head 19a which is spacially related to the armature member 22 which is carried by the balsa wood diaphragm 9. The strip 16 of magnetic material is perforated at 16a to provide a tongue 16b which extends substantially parallel to the pole piece on which the magnetic bobbin 21 is wound and terminates in substantially the same plane as the pole head 19a in spacial relation to the armature 22.

The tongue 16b forms a magnetic return path for the lines of magnetic flux which thread the pole head 19a, and the pole piece on which bobbin 21 is wound, which lines of flux pass through armature 22 and through the magnetic strip 16. Thus it will be seen that by turning knurled head 14a of screw member 14 the magnetic bobbin and pole head 19a and tongue 16b may be advanced toward or retracted from the armature 22 for correspondingly increasing or decreasing the volume of the tick or beat, thereby providing an adjustable metronome, not possible in structures of the prior art.

The securing screw 20, in addition to serving as a fastening means for the angle 19, also serves as a securing means for the angle member 23 to which is fastened the panel 24 of insulation material. The panel 24 provides mounting means for lugs 26 and 27 which serve as terminals for the bobbin 21 which is connected in the electronic circuit of the metronome.

The circuit arrangement in which the magnetic bobbin 21 is arranged has been illustrated in various forms in Figs. 6, 7, and 8.

Referring to Figure 6, the basic system comprises a grid controlled rectifier 28 (gas filled thyatron) in series with the coil of a speaker unit which may comprise any common type loud speaker, telephone head set, or electrical relay indicated generally at 29. The thyatron includes cathode 28a, control grid 28b, anode 28c, and filament 28d, the anode being connected to one side of the alternating current power supply line 30 through switch 31. The cathode 28a connects through the unit 29, and through the basic timing circuit 32 with the opposite side of the power supply line 30, which may be the domestic 110V A. C. power line. The basic timing circuit 32 consists of resistor 33 shunted by condenser 34. The values of the components in the basic timing circuit 32 are very critical, and the product of the values of the resistance 33 and the capacity 34 must equal a time constant of .45 second. Across the line 30 is an adjustable tap resistance 35 and a fixed resistance 36 connected in series. The adjustable tap 35a is connected to the control grid 28b of the thyatron 28 through a resistance 37 adapted to limit the flow of current into the grid circuit. A filament heating transformer 38 is also provided to heat the filament 28d of the thyatron. The value of resistance 35 is 20,000 ohms  $\pm 5\%$ , and the value of resistance 37 is 910,000 ohms  $\pm 20\%$ , while the value of resistance 36 is 6200 ohms  $\pm 5\%$ . The ratio of the value of resistance 36 to 35 is as 31 to 100 and that ratio in conjunction with a time constant of .45 second, which represents the prod-

uct of the values of components 33 and 34, gives a desirably spaced calibration for the metronome.

Capacitor 34 is connected in parallel with a resistance 33 and a glow type (neon) lamp 39 or filament type of lamp. The thyatron circuit includes input means 30—35—36 and 37 and output means 29—38. The input and output means are coupled through the basic timing circuit 32 as shown. The operation of the circuit is as follows: When the switch 31 is closed and the thyatron filament 28d is heated to operating condition, on the half cycle of A. C. potential, and when a positive voltage is applied to the anode 28c of the thyatron 28, it will conduct and a pulse of current will flow, charging the capacitor 34. This pulse of current flowing through the unit 29 will cause the unit to emit an audible tick or beat. Simultaneously with the charging of the condenser 34, the voltage thereon is applied to the terminals of the neon lamp 39 which then glows.

As the cathode-anode voltage of the thyatron 28 reduces owing to charging of the condenser 34 and the alternation of the A. C. voltage is applied to the plate 28c, a point is reached where the thyatron is extinguished. The condenser 34 discharges through the neon lamp 39 and resistance 33 until a voltage between thyatron-cathode and anode again is sufficient so that for a positive cycle of voltage the thyatron again fires and the cycle is repeated.

During the period when the condenser 34 is discharging, when voltage across the condenser is reduced sufficiently, the neon lamp 39 is extinguished. The condenser continues to discharge through the shunt resistance 33 only.

Adjustment of the voltage applied to the thyatron grid 28b by means of the adjustable tap resistor 35 determines the cathode-anode voltage required for refiring the thyatron, and thus determines the time delay between successive pulses. Thus the circuit provides means for creating both audible and visual signals at timed intervals. Inasmuch as the pulse occurs when the anode 28c is positive, the device tends to repeat its pulsing in an integral number of half cycles of the A. C. waves supplying the system. And thus the precision of repetition is controlled by the precision of the power line frequency which is generally so accurate that synchronous electric clocks are continuously operated thereon. The basic timing of this system is controlled by the resistance-capacitance combination 33—34, and the setting of the tap 35a on resistor 35.

In practice, the resistor 35 is a potentiometer having the calibrated scales shown in Fig. 1. While a wide range of frequencies is obtainable, for musical work the range between 40 and 208 beats per minute is preferred. This is obtained by proper choice of the time constant 33—34, and of resistors 36 and 35. Resistor 36 can be so chosen that a desired range is covered by the maximum excursion of the tap on resistance 35.

One undesirable feature of the Fig. 6 is that the timing and calibration is influenced by the characteristics of the neon lamp 39. In order to overcome this objection the circuit of Fig. 7 is provided.

In Fig. 7 the basic circuit is the same as that of Fig. 6 except that the neon lamp 39 is connected in series with a parallel resistance-capacitance combination 40—41. This network is connected across condenser 34 as shown. Operation of the circuit involving resistors 36—35—37, thyatron 28, speaker 21, resistor 33

and condenser 34, is the same as described for Fig. 6. However, when a current pulse charges condenser 34, the voltage thereon causes the neon lamp 39 to glow for an instant while current through it charges condenser 40. When condenser 40 charges sufficiently, the voltage across the lamp 39 becomes so low that it will not maintain a discharge, and is thus extinguished.

By this expedient, the current flow through the lamp 39 exists for a small part of the time interval during which condenser 34 is discharging. Inasmuch as the discharge current through the lamp 39 occupies a small fraction of this total discharge current, variation of lamp characteristics have a minimum effect on the timing, and pulse repetition rate of the circuit.

Between pulses, while the lamp 39 is extinguished, the capacitor 40 discharges through resistor 41. It is desirable that the time constant 40—41 be approximately the same as that of 33—40 for optimum operation.

Referring to Fig. 7, I have illustrated a further modified form of metronome circuit in which a thyatron 28 is employed utilizing an auxiliary grid 28e which is externally connected with the cathode 28a and interposed between the control grid 28b and the anode 28c. The cathode circuit includes the speaker winding represented at 27 interposed in series with the basic timing circuit 32. The speaker winding 21 is illustrated as a general case for any type of device which may be magnetically excited at repeated intervals under control of the basic timing circuit 32 and the associated condenser resistor circuit 40—41 with the discharge lamp 39 interposed therebetween.

In Fig. 8 I have illustrated the circuit of my invention utilized as a generator of timed impulses of saw-toothed characteristic represented by the curve 46. The thyatron circuit is arranged in a manner similar to the circuits described in connection with Figs. 6 and 7, except that the power supply circuit 30 connects across potentiometer 43 which determines the voltage impressed between the anode 28c of thyatron 28 through reducing resistance 42 and the filamentary cathode 28d through the resistance 33 of the basic timing circuit 32. The control grid 28b is connected through resistor 37 with adjustable tap 44 operating over potentiometer 43. The filamentary cathode 28d is energized through transformer system 38, as heretofore explained. The 60-cycle alternating current supplied to the power supply terminals 30 is rectified by thyatron 28 and pulses of current delivered at terminals 45 determined by the characteristics of the basic timing circuit 32. By controlling the value of resistor 33 and the value of condenser 34 a saw tooth wave of predetermined periodicity is delivered at terminals 45.

In Fig. 9 I have illustrated a circuit arrangement for a cold cathode type of tube 47 which includes cold cathode 47a, control grid 47b and plate 47c. Alternating current or direct current is applied at terminals 30 to the circuit of the cold cathode tube 47 between anode 47c and cold cathode 47a through the basic timing circuit 32 which includes resistor 33 and condenser 34 and through the speaker winding 21. The potential determining circuit, including resistors 36 and 35 is arranged in shunt with the power supply circuit 30 as heretofore explained. The tap 35a connects through resistors 37 to control grid 47b of cold cathode tube 47. The basic timing circuit

32 is connected through gaseous discharge tube 39 to the shunt-connected circuit containing condenser 40 and resistor 41. I have successfully used the type OA4G tube for carrying out the functions of the circuit illustrated in Fig. 9.

In the circuit of Fig. 6, consider that the switch 31 is closed, which applies alternating current power across the filament transformer 38, across 35—36, and across the thyatron speaker unit 21 and the basic timing circuit 32 and the neon lamp 39.

Assume the filament 28d sufficiently heated on the first positive half cycle of A. C. power and the grid 28b will either be positive or negative with respect to the cathode, or at most, a zero potential will exist between the grid 28b and the cathode 23a. The exact condition will depend on the position of the tap 35a on the potentiometer 35. In any event the tube will on this first positive half cycle immediately conduct, feeding a heavy current through the speaker unit 21 causing it to tick and charging condenser 34 to some positive voltage with respect to ground. The peak of this surge will cause the neon lamp 39 to flash as mentioned before, but a charge of current will be left on condenser 34 after the neon lamp 39 has extinguished itself.

On succeeding half cycles the cathode will be positive with respect to the grid of the thyatron 28 and the tube will not again conduct until the charge across condenser 34 has leaked off sufficiently to the resistor 33 so that the bias is low enough to permit conduction. In Fig. 7, a somewhat more refined circuit is depicted. The thyatron is of the screen grid type and could conveniently be such types as the RCA 2050, RCA 2051, RCA 2D21 or RCA 2A4G types. It will be noted the net work 40—41 is connected in series with neon lamp 39. This is so as to minimize the amount of current drawn by the neon lamp 39 so that variations in neon lamps will cause only a very slight variation in the calibration. Net work 40—41 should have approximately the same time constant that net work 33—34 has. A particular type of speaker has been developed for this instrument which is convenient because of its extremely low cost and because the loudness of the tick can be easily adjusted. It will be noted that the coil 21 is supported on a flexible metal frame which is attached to another frame made of wood or other suitable material. The adjusting screw 14 pulls the coil 21 and pole-piece 19a as close to the diaphragm 9 with the armature 22 as is desirable, which causes a variation in the loudness of the tick. Connections are formed from the coil terminals 26—27 to the cathode of the thyatron and to the net work comprising 33—34 and 40—41 and the neon lamp 31. When a surge of current passes through the coil 21 the armature 22 is pulled up, causing the diaphragm 9 to emit a sharp sound.

When a surge of current passes through the coil 21, the magnetic field thereby causes a mechanical force impulse on the armature 22. This momentary force exerted on the armature 22 causes the wood diaphragm 9 to vibrate, giving a loud audible tick. Depending on the adjustment by means of the screw 14 of the gap space between the polepiece 19a and armature 22, the tick may be made loud or soft as desired. As this adjustment is made the quality of sound is also varied. Adjustment can be made so that during an impulse the armature can touch the pole-piece 19a. This produces a loud metallic tick.

While I have described my invention in certain

preferred embodiments, I realize that changes in detailed arrangement of the circuits may be made and I intend no limitations upon my invention other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An electric system for producing audible sounds at a repetitive rate comprising a gaseous discharge rectifier tube having a cathode, a control electrode and an anode, an alternating source of power, one terminal of said power source being connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series to said transducer, an electrical return connecting said time constant circuit to the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power and a variable tap connected between said potentiometer and said control electrode.

2. An electric system for producing audible sounds at a repetitive rate comprising a gaseous discharge rectifier tube having a cathode, a control electrode and an anode, an alternating source of power, one terminal of said power source being connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series to said transducer, an electrical return connecting said time constant circuit to the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power, a movable tap on said potentiometer connected to said control electrode, and a loading resistor disposed in said last mentioned connection whereby a predetermined voltage is applied to said control electrode.

3. An electric system for producing rhythmic beats at a repetitive rate which comprises a gaseous discharge rectifier tube having a cathode, a control grid and an anode, an alternating source of power, one terminal of said power source being connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series with said transducer, a second gaseous discharge tube coupled to said time constant circuit, an electrical return connecting said time constant circuit to the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power, an adjustable tap on said potentiometer connected with said control electrode, whereby a predetermined voltage may be applied to said control electrode.

4. An electric system for producing rhythmic beats at a repetitive rate which comprises a gaseous discharge rectifier tube having a cathode, a control grid and an anode, an alternating source of power, one terminal of said power source being connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series with said transducer, a second gaseous

discharge tube coupled to said time constant circuit, a second time constant circuit consisting of a capacitor and resistor connected in series with said second discharge tube, whereby the amount of current from said first discharge tube through said second discharge tube is minimized, an electrical connection between said time constant circuits and the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power, a variable tap on said potentiometer connected with said control electrode, whereby a predetermined voltage may be applied to said control electrode.

5. An electric system for producing rhythmic beats at a repetitive rate which comprises a grid controlled cold cathode tube having a cathode, a control grid and an anode, an alternating source of power, one terminal of said power source being connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series with said transducer, a second gaseous discharge tube coupled to said time constant circuit, a second time constant circuit consisting of a capacitor and resistor connected in series with said second discharge tube, whereby the amount of current from said first discharge tube through said second discharge tube is minimized, an electrical connection between said time constant circuits and the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power, a movable tap on said potentiometer, a connection between said tap and said control electrode and a resistor interposed in said connection, whereby a predetermined voltage may be applied to said control electrode.

6. An electric system for producing rhythmic beats at a repetitive rate which comprises a gaseous discharge rectifier tube having a cathode, a control grid and an anode, an alternating source of power, one terminal of said power source be-

ing connected to said anode, an electromechanical transducer connected in series with said cathode, a time constant circuit consisting of a resistance and a capacitor connected in parallel, said time constant circuit being connected in series with said transducer, a second gaseous discharge tube coupled to said time constant circuit, a second time constant circuit consisting of a capacitor and resistor connected in series with said second discharge tube, whereby the amount of current from said first discharge tube through said second discharge tube is minimized, an electrical connection between said time constant circuits and the other terminal of the alternating source of power, a potentiometer arrangement connected across the alternating source of power, a variable tap on said potentiometer connected with said control electrode, a resistor disposed in said connection whereby a predetermined voltage is applied to said control electrode and an adjusting screw for controlling the amplitude of said sound reproducer.

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